CLIVAR

The Principal Research Areas

G1: ENSO: Extending and Improving Predictions

Goal:
Advancing understanding and observations of climate variability associated with El Niño - Southern Oscillation (ENSO) and global teleconnections to improve prediction and applications.

Introduction

Scientific Rationale

The WCRP developed, planned, and undertook a major study of the ENSO phenomenon (Fig. 1) based in the equatorial Pacific, the TOGA Programme, which began in 1985 and concluded at the end of 1994. The TOGA Programme succeeded in not only describing and making major strides towards understanding ENSO, but in also showing:

- that certain levels of predictability of SST in the Tropical Pacific exist
- that skillful predictions of SST could be made(Fig.5 and 6);
- that SST predictions indicate some skill for temperature and precipitation in selected other parts of the world ; and
- that these predictions in selected parts of the world could be usefully applied for the amelioration of adverse climatic conditions and for the exploitation of beneficial climatic conditions.

CLIVAR G1: Research Issues

- improving methods of producing analyses using all available information from satellites and in situ observations, both past and present;
- better coupled model initialisation that avoids spurious drifts or problems arising from imbalances in analysed fields;
- development of coupled models for the tropics and their use in predictions; and
- the development of improved prediction of the extra-tropical atmospheric circulation by including improved depictions of teleconnections and interactions with the surface.
- Improving assessments and information for the public has considerable potential benefits.

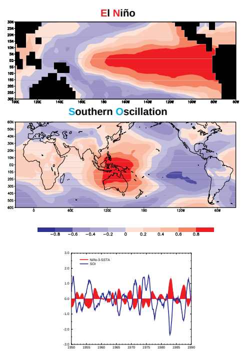


Fig. 1: upper panel: A typical anomaly pattern for the tropical Pacific sea surface temperature (SST) associated with El Niño. Shown is the correlation of annual SST anomalies averaged over the Niño-3 region (5°N-5°S, 150°W-90°W) with all other locations. Middle: Spatial structure of the Southern Oscillation showing the global-scale nature of the phenomenon. Shown is the correlation of annual pressure anomalies at Djakarta (Indonesia) with all other locations. Lower: Time series of the Southern Oscillation Index (SOI; blue line) which measures the atmospheric sea-level pressure gradient across the tropical Pacific basin and of the anomalous SST averaged over the central equatorial Pacific (red line). Both time series are normalized by their standard deviation (courtesy of M. Latif, S. Venzke).

Satellite Measurements

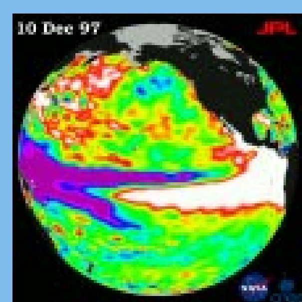


Fig. 2: Snapshot of the sea surface height anomaly relative to normal ocean conditions collected by the altimeter onboard the joint US/French TOPEX/Poseidon satellite on December 10, 1997 during the maximum of the recent El Niño event. The white and red areas indicate unusual patterns of heat storage where the sea surface is elevated up to about 20 centimeters (about 8 inches) and 10 centimeters (4 inches) respectively (courtesy of NASA/JPL).

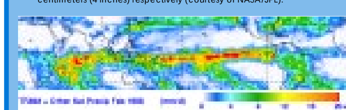


Fig. 3: Precipitation estimates obtained from TRMM and other satellite precipitation fro Feb. 1998. Anomalous strong precipitation due to the positive SST anomalies and strong convection can be found in the central and eastern equatorial Pacific, lower than normal values in the Indonesian region (courtesy of NASA/GSFC, TRMM office).

ENSO 1997/98

The development of the 1997-98 El Niño event into, by some measures, the biggest on record in over a century has given the CLIVAR community a wonderful opportunity to exploit an experiment mounted for us by nature. This event is the best observed ever and the worth of the TAO moored buoy system straddling the equatorial Pacific has been clearly demonstrated by its ability to provide data that firstly showed the evolution of subsurface temperature anomalies and secondly was very useful for initializing models for successful prediction of the future evolution. "El Niño" is in the public vernacular. All kinds of things have been blamed on El Niño when sometimes there is at best a tenuous link. A new aspect of this event is that it was predicted by CLIVAR scientists well in advance, and forecasts were widely disseminated. But how good were the forecasts? Were the expressions of uncertainty appropriate? Were the forecasts used? And were they misused? How can the links to El Niño be established and impacts attributed?

Clearly, this event demands a careful, in-depth analysis of its many aspects and has lessons for CLIVAR. It is expected that several workshops and conferences will touch on aspects important for a full retrospective examination of the 1997-98 event. There are a huge number of possible subtopics, with many of direct concern to CLIVAR.

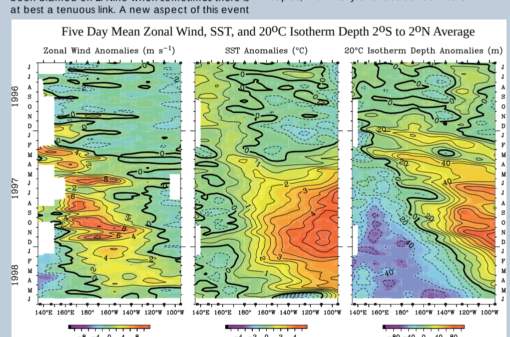
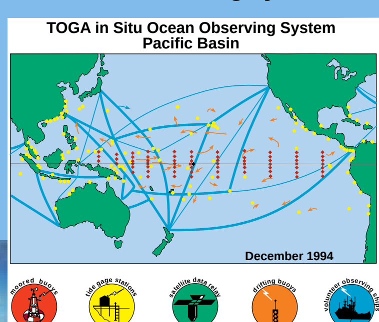
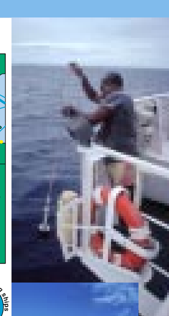


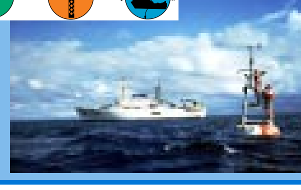
Fig. 4: Time / longitude sections of anomalies in the surface zonal winds (in m s^{-1}), SST (in °C) and 20°C isotherm depth (in m) for the past 24 months. Analysis is based on 5-day averages between 2°N-2°S of moored time series from the TAO array. Anomalies are relative to monthly climatologies cubic spline fitted to 5-day intervals (COADS winds, Reynolds SST, CTD/XBT 20°C depths).
Positive winds are westerly. Squares on the abscissas indicate longitudes where data where available at the start of the time series (top) and at the end of the time series (bottom). The TAO array is presently supported by the US (NOAA Office of Global Programs), Japan (JAMSTEC), Taiwan (NSC), Korea (STA) and France (ORSTOM). Further information is available from Dr. M.J. McPhaden (NOAA/PMEL) (courtesy of NOAA/PMEL).

The ENSO Observing System

The ENSO observing system build up during the TOGA period (right panel) is one of the main cornerstones for successful prediction of ENSO events. Without a continuous collection (in space and time) of different meteorological and oceanographic data using the capabilities of research vessels, ships of opportunity, surface and satellite observations and the evolving knowledge and technology of climate modelling successful forecasts of ENSO events would not be possible. Compared to the benefit of the society the cost for the maintenance of the observing system and the modelling resources are neglectable.

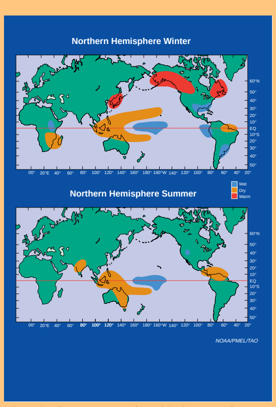




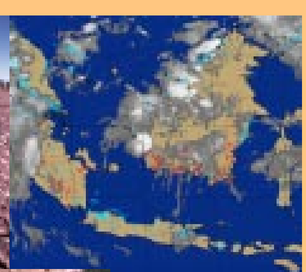


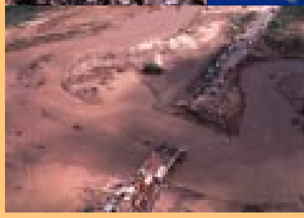
Photos: above and right: maintenance of the TAO array (courtesy NOAA/PMEL), upper right: "classical" sea surface temperature measurements (bucket) (courtesy G. Meehl)

ENSO Impacts



Schematic of temperature and precipitation anomalies generally associated with the warm phase of ENSO during the northern winter and summer seasons. To a good approximation, relationships with the cold phase of ENSO are simply reversed in sign. [After Halpert and Ropelewski (1992, J. Climate, 5, 577-593) and supplemented by Aceituno (1988, Mon. Wea. Rev., 116,505-525)] (courtesy of NOAA/PMEL).





ENSO events have tremendous impact in various regions of the world. For example, warm ENSO extremes are accompanied by droughts in parts of Africa, south-east Asia, Australia and Brazil and flooding in western South and North America and Florida.

Photos: upper left: drought in southern Africa during the 1982/83 ENSO event (© T. Nebbia), left: flooding in Equador (1982) (© T. Nebbia), above: fires in the tropical forest of Indonesia (red dots), snapshot on September 30, 1997 (courtesy of NOAA/Significant Event Imagery)

Successful Predictions

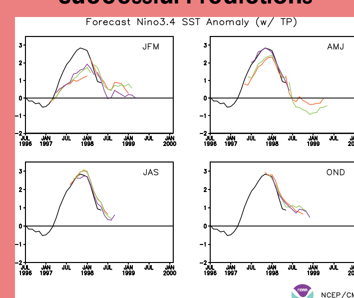


Fig. 5: Plume diagrams of the evolution of forecasts of SST anomalies in the tropical Pacific from NCEP for the Niño 3.4 region. The continuous line is the observed and forecasts issued from the months given at upper right in each panel for a year ahead (courtesy Vernon E. Kousky, NOAA).

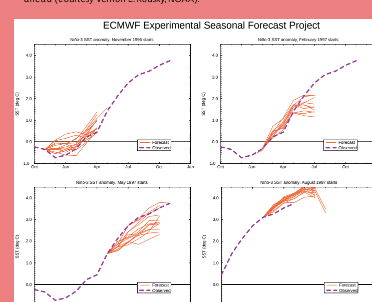


Fig. 6: Plume of monthly mean SST anomalies predicted for the Niño 3 region for forecasts initiated in a) November 96, b) February 97, c) May 97 and d) August 97. Three forecasts are initiated weekly and run for six months. The heavy line shows the observed values. From the ECMWF Seasonal Forecast Project page.

Some Lessons from the 1997-98 El Niño Event

- Possible activities -

The following lists some initial suggestions for activities, it is not intended to be comprehensive.

On the physical climate side:
- description of event: gathering requisite datasets
- diagnosis of processes, empirical studies
- verification of numerical predictions, forecasts
- development of forecast verification techniques, especially using ensembles
- implications of the event for the observing system
- implications for model development
- numerical experimentation
- the role of global warming
- attribution of local and regional climate anomalies to the event,
- any process studies that should follow?

On human dimensions and applications side:
- proliferation of "information" (e.g. on the www) of mixed quality
- attribution of impacts to El Niño
- impacts of El Niño
- costs/damage and benefits of El Niño
- actions taken because of forecasts (whether useful or not)
- impacts of actions not taken
- impacts of busted forecasts where actions were taken
- assessment of information available
- utility of information
- effectiveness of communication and dissemination of information
- benefits of forecasts (mitigating losses etc.)
- assessment of user needs and how well they were met.